A PRELIMINARY STUDY OF SOME OF THE MOTOR PHENOMENA OF MENTAL EFFORT.

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These pages represent the result of an examination of data gathered by questionnaire and by direct observation, dealing with some of the motor phenomena of mental effort. Chief attention is devoted to the study of those postures and movements, rich in variety and little understood, namely, "common motor automatisms."

The following cases from the questionnaire reports will furnish a more definite idea of the material studied. "When studying I often find myself playing with pencil, holding it first on one end and then on the other, or twirl watch-chain. Often look steadily at some distant point, and at such times often squint and slightly frown." Another person "when thinking, frowns, moves uneasily on chair and bites finger nails." A third "always scratches head before attempting anything difficult."

It must be noted that the word "automatism" does not here have the more narrow and technical connotation ascribed to it in psychological texts. Here the term is made to include not only some movements initiated from within, but also many set going from without. It comprehends all tricks and peculiarities of movement and posture, whatever their origin, which have become more or less unconscious, and which accompany mental effort. No attempt is made to separate these common automatisms from the so-called normal expressions of mental effort, partly because the line of demarkation seems a vanishing one, and largely because both classes of phenomena must be studied in their relations to each other if either is to be understood. Both belong to a somewhat neglected chapter of psychology, and both sustain highly important relations to fundamental problems. They may not only

throw new light on the nature of attention and its mechanism, but also furnish important data with regard to mental development.

Returns from the Questionnaires.

The materials for this study were from three sources:

1. Most of the data were observations sent in response to a part of President Hall's Syllabus X (series '95). The topic in question reads as follows:

III. *Effort Automatism.* Describe the unconscious acts that accompany work or fixed attention—as during recitations,—as biting tongue or lips, chewing a stick or nothing, winking and blinking, twisting buttons, handling articles of dress, playing with fingers, swaying, rocking, rising on the toes, standing on the sides of the feet, turning away, fixating a distant point with the eyes, wriggling, writhing, tapping, drumming, scowling, squinting, tics, grimaces, pulling finger to snap the joints, moving the ears, putting finger in the mouth; whistling, singing and dancing at work. What indicates the hardest effort — as the fidgets or habit chorea seen just before great athletic feats — shutting eyes or ears, moving lips; tunes, verses, etc., persistently running in the head? Is the fœtal posture approached? Does fatigue increase or diminish these movements? Order and per cent. of frequency and duration? Should some be encouraged for better work? At what age are they most common? Treatment?

2. A smaller number of replies to a part of question II of the syllabus issued by President Hall and Dr. Lukens, entitled, "The Beginnings of Reading and Writing." The points in question were as follows: Describe (1) accessory, automatic movements of tongue, lips, hands, eyes, head, legs, feet or body, while writing; (2) ditto while reading.[1]

3. Observations made by the writer, with the coöperation of Dr. Hall in the kindergarten and primary grades of the Boston Normal Training School.

The total number of cases reported was 662. This does not represent, however, the number of persons represented, inasmuch as the same individuals were observed at different times, and therefore each separate record constitutes a case.

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[1] Nearly all the data in reply to the above syllabi were gathered under the able direction of Miss Lillie A. Williams, by the members of her classes in psychology, at the State Normal School, Trenton, N. J. The collection of such data is made a special feature of the child-study pursued there, and the very great care with which the work is done is shown by Miss Williams' article, "How to Collect Data for Studies in Genetic Psychology," in the *Pedagogical Seminary*, Vol. III, No. 3. Our returns, therefore, possess high value, and their great importance in this study is gratefully acknowledged.

While it would be of great advantage to know exactly the number of persons reported on, the replies to the questionnaires were often of such a nature as to preclude accurate determination of this point. Of these 662 cases 235 were of children twelve years of age or under. Of the remaining 427 cases, nearly all are under twenty years of age, the ages sixteen to nineteen furnishing more than half of the 427 cases. We have named the group containing all those over twelve adolescent, inasmuch as it includes only twenty-seven adults, nineteen of whom are men and eight women.[1]

Of the total 662 cases, 421 were females, 241 males. Of the 235 children, there were 117 girls and 118 boys. Of adolescents, 304 were females, 125 males.

The grouping of the automatisms has been a point of considerable difficulty. The system chosen is manifestly rough and imperfect, but was determined as far as possible by the nature of the actual returns. It is as follows: —

Head: Held on side, move sideways, move up and down, move with pen, jerky movements, move.

Face: Grin, grimace.

Eyes: Fixed, wink, close, twitch, roll, squint, bulge.

Ears: Move.

Forehead: Wrinkle, frown.

Mouth: Twitch, drop corners, chew, move.

Jaw: Bite, chew, put objects in, clench, move sideways.

Lips: Draw in and out, pucker, move, work, bite, press, twist, suck, chew.

Tongue: Protrude, move sidewise, move in and out, move with pen, bite, chew, roll, in one cheek, suck.

Hands: Play, clasp, clench, rub or scratch, put in pockets, wriggle, pull hairs, etc., twist hair, smooth, put objects in, move.

Fingers: Play, drum, mark on paper, move up and down, point, move, snap or pull.

Arms: Fold and unfold, jerky movements.

Body: Sway, twist, shrug shoulders, fidget, rock, turn away, move.

Legs: Cross, move, move knees, twist, raise heel, twist heel.

Feet: Sides of feet, stand on one foot, right on left, left on right, rise on toes, rock, lift one foot, move, stamp, wriggle, cross, tap, shake.

The movements and postures are thus distributed among

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[1]This inclusion, as adolescent, of women over twenty-one and of men over twenty-five, is open to criticism, but the numbers are very small, and make practically no difference in the results.

ninety-two classes. Forty-five of these represent the region of the head, twenty the feet and legs, nineteen the hands and fingers. This latter number does not show adequately the relatively great variety in movements of hands and fingers, inasmuch as the classification here was more general.

The following table is designed to exhibit the distribution of automatisms among the different parts of the body, as well as to show the order of frequency of automatisms in children as compared with adolescents.[1] In the last column of the table appears the order in which the automatisms of children preponderate over similar ones of adolescents. The last five items are followed by the minus sign, to indicate that in these classes the automatisms of children are less frequent than in adolescents. In all the others, as indicated by the plus sign, the children show the largest number, those of the head having greatest advantage, mouth next, and so on. This is important as roughly indicating the shiftings of the locality of the automatisms due to age. The numbers with which all the tables deal are manifestly too small to render the ratios anything more than suggestive. The difficulty of observing all the expressive movements of an individual at any given time, is very great, and when we reflect that a large number of cases reported are results of self-observation of these, at best, only semi-conscious movements, it appears highly probable that our totals are too small. Some movements, moreover, such as slight pressure of the lips, contractions of muscles of covered parts of the body, and the like, elude observation more easily than the larger muscular contractions. This source of error tends to narrow the variety of automatisms. Both the above mentioned defects, then, produce underestimation rather than overstatement of the actual phenomena.

In the first part of the table, the numbers opposite each item represent the number of given automatisms in a thousand. In these calculations 1,000 is used as a basis instead of 100 (as in percentage), simply for convenience, in that it yields larger numbers and fewer fractions, without, of course, destroying the original proportion. The method of calculation is as follows. The children, for instance, show thirty-eight body automatisms. This number is divided by 897, the total number of automatisms from all sources, and the result is multiplied by ten, yielding forty-two, which represents the number of cases of body automatisms in a thousand autom-

[1] In the discussion of the tables, the word automatisms is used for convenience, to designate expressive movements as well as common motor automatisms.

TABLE I.

Relative Frequence of Automatisms.

	I Ch.	II Ad.	III Ch. (1.81)	IV A	Order of frequency in children.	Order of frequency in adolescents.	A′
Fingers	81	143	146	102	Fingers	Fingers	Head+
Feet	72	57	130.3	228	Feet	Feet	Mouth+
Lips	71	53	128	241	Lips	Eyes	Legs+
Tongue	57	26	103	396	Tongue	Lips	Tongue+
Head	48	8	86.8	1085	Head	Hands	Face+
Body	42	33	76	230	Body	Jaw	Lips+
Hands	32	49	57.9	118	Hands	Forehead	Body+
Mouth	20	6	36.2	603	Mouth	Body	Feet+
Eyes	15	56	27	48	Eyes	Tongue	Hands+
Jaw	13	49	23.5	47	Jaw	Head	Fingers+
Legs	6	2	10.8	540	Legs	Mouth	Arms—
Forehead	5	34	9.05	26	Forehead	Legs	Eyes—
Face	3	2	5.43	271	Face	Face	Jaw—
Arms	1	2	1.81	90	Arms	Arms	Forehead—
Ears		2			Ears	Ears	Ears—

Explanation of Table. Columns I and II represent children and adolescents respectively, and indicate the number of given automatisms per thousand. In column III, the ratios of I are multiplied by 1.81 in order to render the numbers for children more easily comparable with those of adolescents ; there being 1.81 more adolescents than children reported. In IV *A* is expressed in percentages the proportion of children's automatisms to those of adolescents. For instance, in "fingers," children show 146, while adolescents furnished only 143. The 146 of children is 102% of the adolescents, etc. In *A′* these percentages are arranged in order and the *plus* sign indicates preponderance in favor of children ; *minus* sign indicates preponderance of given automatisms in adolescents. The remaining columns show the order of frequency of the different automatisms in children and adolescents respectively.

atisms observed. The average number of automatisms per hundred children is 176, of adolescents 110. If, however, we subtract all the cases of "writing" and "reading" automatisms reported at another time, in addition to those observed by the present writer, the average for the children is reduced to 124, while the adolescent average remains 110.

Let us now consider briefly some of the more striking details. About half of the total number of automatisms belong to parts of head and face. Of single groups recorded, however, "fingers" and "feet" lead in both children and adolescents. In the latter "fingers" show a great advantage over the other automatisms. The "feet" automatisms, however, especially in children, include many cases of mere posture rather than of movement, as standing on sides of feet, and the like. The "lips" rank high in both lists. The connection of these muscles with speech as well as with the gustatory mechanisms would lead us to expect high rank in the table. In the order of greatest relative frequency in children as compared with adolescents, those of "head" show a very great predominance, while those of "mouth," "legs" and "tongue" also exhibit considerable advantage. Of the two most prominent groups in each list—those of "fingers" and "feet,"—it seems evident that there is little decline due to age. The growing relative importance of "eyes" and "forehead" is significant. These are considered the intellectual muscles par excellence, and the above figures indicate the gradual settling of expression in the face. The relative prominence of body automatisms is slightly obscured by the large number of head movements and postures, which are introduced by the writing, reading and kindergarten groups. Of these body automatisms, the most frequent is swaying, and nearly all the cases reported are of children. Playing and drumming with fingers are not so frequent with children as among adolescents. This may be due to the fact that children have as yet no very great ability to make the finer movements of fingers.[1] As between boys and girls, the latter lead greatly in swaying the body, and considerably in finger automatisms, while the boys show greater frequency of tongue, feet and hand movements. Some of these facts are perhaps explainable as due to the greater conformity on the part of the girls to social custom, which would tend to gradual suppression of the more marked of such movements. The average number of automatisms per 100 girls is 179, of boys 181. The quantitative differences

[1] "Development of Voluntary Motor Ability," Bryan (AM. J. PYSCH., Vol. V, No. 2), and "Preliminary Study of Motor Ability," Hancock (*Ped. Sem.*, Vol. III, No. 1).

TABLE II.

Classification of Automatisms According to the Activity that they Accompany.

	Writing.		Reading.		Reciting.		Public recitation.		Conversation.		Attention; interested.		Studying.		Difficult recollection.		Greatest effort.	
	Lips	240	Body	240	Feet	253	Fingers	433	Fingers	421	Feet	196	Fingers	197	Eyes	339	Lips	238
	Tongue	220	Head	180	Fingers	190	Body	170	Hands	131	Fingers	175	Hands	120	Hands	190	Hands	195
	Head	170	Hands	140	Body	166	Eyes	170	Forehead	105	Hands	163	Jaw	120	Lips	127	Forehead	173
	Feet	170	Fingers	140	Eyes	130	Hands	113	Legs	105	Lips	103	Lips	116	Body	84	Eyes	86
	Mouth	87	Feet	110	Hands	120	Feet	56	Eyes	78	Eyes	93	Eyes	73	Head	63	Jaw	65
	Forehead	24	Lips	55	Jaw	47	Head	18	Jaw	78	Forehead	92	Feet	67	Forehead	63	Fingers	65
	Body	24	Tongue	36	Forehead	23	Jaw	18	Body	52	Jaw	91	Tongue	64	Fingers	63	Feet	43
	Legs	24	Arms	18	Lips	23	Lips	18	Head	26	Legs	21	Body	55	Feet	63	Tongue	43
	Jaw	14	Jaw	18	Head	15					Body	21	Forehead	43	Jaw	60		
	Hand	4			Face	15					Head	10	Legs	30	Face	21		
	Fingers	4			Arms	15					Ears	10	Face	12	Mouth	21		
													Head	8	Tongue	21		
													Arms	8				
													Ears	4				
Number of cases.	96		28		109		44		28		47		170		29		30	
Average per hundred.	214		180		110		120		100		136		130		160		150	

The columns read vertically exhibit the order of frequency of the different automatisms, the numbers opposite the items representing the ratio of the frequency of the given automatism on a basis of one thousand.

due to sex are thus so slight that they are disregarded in further treatment of results.

In order to determine the effect of various kinds of activity and of posture resulting therefrom, the following groups were made, namely, automatisms of Writing, Reading, Recitation, Public Recitation, Conversation, Attention, Study, Difficult Recollection, and Greatest Effort. Such classification, especially in the last five groups mentioned, is obviously more or less arbitrary, but such lines of cleavage seemed to exist in the reports.

Without entering into all the details of Table II, certain general conclusions seemed justified by it.

1. The automatisms tend to vary with the nature of the activity in question. Contraction of certain muscles tends to predominate in writing, while others are most frequent in recitation, etc. In writing, lips and tongue furnish 46% of all the automatisms; in reading, body, head, hands and fingers comprise more than half the whole number; in recitation, feet, fingers, and body lead; in study, fingers, eyes, hands and jaws are most prominent; and so on. This variation is partly due to the manner of accomplishing the task in hand. There will be few automatisms of those muscles directly involved in a given task. Thus in writing, the hand shows few automatisms; in reading, the mouth, lips, tongue and eyes, very few. Another factor in differentiating the automatisms is posture. Those activities which involve standing would show, if everything else were equal, a slight difference in distribution of automatisms from those in which a sitting posture is taken. Swaying of body seldom appears when the subject is sitting, while of course standing on one foot or on the sides of feet, and the like, must depend on a standing position of the body. Again, when those parts which in the general table show greatest frequency of automatisms are pressed into actual performance of work—as the fingers in writing and vocal organs in reading,—the number of automatisms is not thereby apparently diminished. The wave of diffusion simply floods into the most susceptible of the paths remaining free.

A further point, of some significance, remains to be noted. The average number of automatisms per hundred persons appears to increase slightly with intensity of the effort. We exclude reading and writing data, which were collected under different circumstances, and are thus not strictly comparable with the other categories. Recitation, public recitation and conversation show an average of 120 automatisms per hundred persons. Attention, study, difficult recollection and greatest effort yield 136. The numbers dealt with are too

small to give very high value to the averages, but the result raises the important question: Does increase of effort increase the number of automatisms?

Observations in Boston Normal Training School.

It seemed desirable to attempt a more exact determination of the automatisms of young children; the following tests were therefore made in the kindergarten and primary grades of the Boston Normal Training School.[1]

The first series of observations was conducted in the kindergarten. On paper ruled so as to furnish alternate groups of lines, 4 mm. apart and 2.8 cm. respectively, the children were set to drawing lines, zig-zag or vertical, using top and bottom lines as boundaries. They were first to draw large lines for a certain time, then after a short period of rest, small lines for about the same length of time. The order of large and small movements was of course varied, small coming first about as often as large.

The children were arranged in successive groups of six or eight, and those of about the same age were placed in the same group. They were seated at the kindergarten benches, ample room being given, and were asked to "make soldiers" (straight lines), etc. They were urged to do the best work possible. The first group consisted of eight children, four girls and four boys, aged as follows: four girls, six years; two boys, six years; two boys, five years. They were allowed in the first instance to work at the large movements for about fifteen minutes, the time being lengthened in order to see what were the effects of fatigue. After a rest of about five minutes, the small movements were made for about ten minutes. This group showed from the first the most marked automatisms of any of the children tested. The second group (six children—four girls, two boys; girls three and one-half years, boys four) worked at large movements for ten minutes; then, after the usual period of rest, they made small movements for ten minutes. The number of automatisms was much less than in the preceding group. This may be partly due, however, to the fact that these younger children put forth less effort. The intermittence of their work tends to corroborate this view. The third group (eight children–four girls, four boys; girls five years; two boys five; one boy four

[1]For the opportunity of making these tests the writer is indebted to the courtesy of the Boston School Board. The facility of taking them was greatly increased by the kindness of Miss Aborn, in charge of the kindergarten.

and one-half years, the other four years) executed small movements for ten minutes, and then took large movements for the same length of time. The fourth group (seven children—four girls, three boys; three girls five years, one girl four; two boys four, one five years) executed large movements ten minutes, and followed with small movements for same length of time. In the primary grade the same general conditions were observed as above, but the time was lengthened and a large number of pupils participated. Ages of pupils six to seven years. The automatisms were strikingly less energetic and less frequent than in the kindergarten, many of the pupils showing no marked automatisms of any description.

The following is a summary of the observations made:

FIRST SET.

A. Large movements, fifteen min. M.[1] Left foot on side, lips pressed and moved slightly. M. Left foot on right one and twisting of left foot. Right foot on side. Lips pressed and moved with pencil. F. Head down, lower lip to one side, tongue slightly protruded or in one cheek. F. Left foot on right, lower lip moved slightly, knees moved. M. Right foot on left, shifting of feet. F. Head down, lips protrude, mouth moves with pencil. M. Right foot on left, left foot on side. F. Mouth open, head moved.

B. Small movements, seven min. M. Right foot on side. M. Lips move. F. Tongue moved in cheek. F. Legs crossed, lips moved slightly. M. Head on left side, later on left arm. M. Left foot on side, right foot on left, bent over his work, lips pursed. F. Right foot on left, tapping with right toe.

SECOND SET.

A. Large movements, ten min. F. Mouth open, tongue in cheek. M. Tongue out. F. Head down, lips strongly pursed, changed style and position often; pencil in fist, head on left arm. M. Tongue in cheek. F. Lips protruding. M. Scowl.

B. Small movements, ten min. F. Feet back and on sides. Head moved, lips pursed, then ajar, or twitching slightly. M. Left foot on right, lips open, or twitching slightly with movements of pencil. Tongue out. F. Right foot on left. F. Used both hands, then held pencil in fist. Head moved up and down with stroke of pencil. M. Left foot on right. Tongue in left cheek, then moved to other cheek. M. Lips set. F. Right foot on left, lips set. M. Frown, lips set, mouth moved slightly, left foot on right.

THIRD SET.

A. Large movements, ten min. F. Head down, almost to paper, tongue out, left foot on right. F. Mouth twitched slightly. M. Lips set, compressed more tightly in a rhythmical manner. Changed hands. F. Head down, left foot on right. F. Lips pursed, chin puckered, head on left side; theatrical, self-conscious. M. Tongue out, left foot on right. M. Frown, head close to paper, left foot on right.

[1] F. and M. are abbreviations for "female" and "male" respectively.

B. Small movements, ten min. F. Lips pressed, move with pencil, head lower than above, shook his hand in imitation of the third boy. F. Head down, lips move while pressed. Later shook her hand, seemed tired, and lips moved more. At close of time stretched. M. Tired, shook his hand and said he was tired; head lower. F. Head lower, left foot still on right at times. F. Same as above, except somewhat more marked; head lower. M. Tongue out, position about same as in former test. M. Frowned more strongly, head lower, left foot on right; stretched at close.

FOURTH SET.

A. Large movements, ten min. M. Left foot on right, lips pursed, mouth open and moved slightly. M. Tongue partly out, lips and tongue moved slightly. F. Writing with crossed hands, left-handed. Right foot on left. F. Right foot on left.

B. Small movements, ten minutes. M. Moved mouth slightly. M. Best worker, moved mouth slightly. F. Upper lip drawn in, tongue out little way. F. Changed hands toward end; talkative. F. Changed to left hand.

PRIMARY SET.

A. Large movements. M. 6. Head on left arm, lips set, but moved slightly. Head rotates. M. Head very low. F. 6. Head very low. F. Lips pressed and moved. F. 6. Head low, lips pressed. Head on side, tongue slightly protruded. Three F.'s with right foot on left.

B. Small movements. M. 6. Lips move more than when making large strokes; head lower and on one side. F. 6. Head at first inclined backward, then lower, right foot on left. F. 6. Tongue out slightly; body swayed to and fro.

The following general statements seem warranted by the above observations :—

1. The automatisms increase in number and intensity with age in the kindergarten groups, the class containing those of ages three and one-half to four years showing fewest and feeblest. The pupils in the primary grade, however, showed a great falling off in frequency and intensity of automatisms. This latter result is to be expected, inasmuch as the task was relatively easy for children of six or seven years. But the increase of automatisms in kindergarten with age is difficult to understand. Of course the number of cases observed is too small for statistical treatment, but the differences apparently due to age were certainly striking in the cases observed, and suggest the need of more extended observation and experiment. The youngest children seemed little capable of any considerable sustained effort, and in this fact may lie, as has been suggested, the explanation of the small number of their automatisms. Their automatisms were chiefly those of posture.

2. The automatisms were more pronounced in the making of small movements. In many cases the head was brought lower, the body assumed a more collapsed position, the lips

were either pressed more tightly or moved more perceptibly, and other movements were intensified. This suggests the very much greater difficulty of fine work for the child.

3. A majority of the pupils showed marked symptoms of fatigue before the close of the ten minute periods of work. Some shook the hand that held the pencil, others changed the pencil to the other hand. Holding the pencil in the fist, sighing, stretching, shifting positions of body, and frequent intermittences in the work were also noted in some cases; several also said they were tired. In nearly every case the automatisms showed a somewhat rapid increase toward the end of the work period. The surprisingly short time which a young child can work with sustained attention, suggests the need of more scientific determination of the proper period of effort than has yet appeared. The very great fatigue produced by the small movements of hand and fingers, emphasizes what has already been noticed by others, namely, the danger of requiring fine and precise work from young children. *Automatisms are thus a sign of the difficulty of tasks*, and the more intense automatisms exhibited by the children simply show that the given task demanded a degree of skill which they were not yet prepared to acquire. Further tests also in the lower grades of the elementary school might aid in determining at what age writing and other school subjects should be introduced.

Attention may be called in passing to the very great frequency of automatisms of posture. So many placed the feet on the sides, or the side of one foot on the other leg, or assumed collapsed positions of body while at work, that one can hardly escape the suggestion that here we may have that reversion to fœtal posture, noted by Preyer and others as very frequent in children much younger. This point will be further considered below.

Effect of Fatigue.

In answer to the question, "Does fatigue increase or diminish these automatisms?" the replies were not sufficient in number to be decisive. Thirty answered the question. Of these, twenty-three thought that fatigue always, or at least generally, increases the number or prominence of these movements and postures; four thought they diminished with fatigue, and three answered as follows: F., 21: "When fatigued, do not press teeth so tightly, but either rock or tap foot, or drum with fingers." F., 22: "Nervous fatigue increases movements, otherwise fatigue diminishes movements." F., 18: "Have seen intellectual fatigue increase

wriggling." Although in the state of exhaustion there is certainly a loss of muscular tone and a general inability to put forth more than a minimum of effort, it seems probable that in lesser degrees of fatigue there is an increasing restlessness and a distinct rise in the number of the common automatisms as the individual continues at his task. Galton[1] writes, "Restlessness appears to be the commonest sign of partial fatigue." The store of energy is waning and every resource of the mechanism of attention is taxed to call out the whole store of power. The rapid increase in the feeling of effort as fatigue comes on, must in part be due to the increased tension of the muscles in this attempt to arouse all the energy possible. In general, fatigue tends to affect the higher centres first. Inhibition is thus decreased and the motor centres tend at the least stimulation to break out in more or less random movements. Galton mentions the following movements observed during fatigue: sudden muscular movements, grimaces, frowning or compression of lips, twitching of fingers, face, twitching and blinking of eyes, fluttering of eyelids, tendency to nervous laughter or movements. The general unsteadiness of muscular coördination is shown by bad and shaky handwriting.[2]

On the whole, therefore, in view of the diminution of the store of energy and the decline of inhibition, we may expect, in many cases at least, an increase in the number, but a gradual diminution in the intensity of the automatisms when effort is continued during fatigue.

Conclusions. The returns would seem to justify the following general statements:

1. Automatisms of accessory muscles are most frequent. Muscles of the face and head and the fingers and feet furnish a large majority of the total number.
2. Automatisms of the fundamental muscles (body, legs, arms) disappear rapidly with age.
3. In general, automatisms decline in frequency with age. But an increase with age is marked in the frequency of certain specialized contractions, and indicates the gradual settling of expression in the face. The movements of eye, brow and jaw show greatest increase with age.
4. Automatisms show greater individual variation than do the specialized contractions which they accompany.
5. Sex has little influence upon the relative frequency of automatisms.
6. Automatisms vary with the nature of the work and the general posture of the body.

[1] "Mental Fatigue," *Journal Anthropolog. Inst.*, XVIII, 2.
[2] Galton, *ibid.*

7. Automatisms tend to increase in number with fatigue.
8. They increase in intensity and often in number, with increase in effort.

General Considerations.

The present section is devoted to an attempt to classify and interpret the motor phenomena of effort. As a brief résumé of the data to be explained, the following synoptic table of the expressions of thought, taken from Mantegazza's *Physionomie*,[1] is transcribed:—

"1. *Contractions and relaxations of the muscles of the face.* Contraction of brow muscles, immobility of the eyes, erratic contractions of all the ocular muscles, immobility of all the muscles of the face, exaggerated opening of the eyes, closing or semi-closing of eyes, depression of lower jaw, extreme elevation of one brow, partial or total convulsions of the facial muscles.

"2. *Contractions of the trunk.* Immobility of the whole trunk, catalepsy, partial or total convulsions.

"3. *Sympathetic movements and the more frequent rhythms of members.* Scratching of head, forehead or nose, feeling or touching the head, tapping the forehead or taking the head in one or both hands, caressing cheek or chin, rubbing eyes vigorously, shaking the head, making rhythmical gestures with arms or hands, making rhythmical noise with feet or hands, moving legs incessantly and rhythmically, closing the ears with the two hands."

These movements and attitudes seem to belong to three types:

1. Those which represent specialized contractions; as adjustment of sense organs and the other concomitant changes in the so-called "muscles of expression." These are chiefly facial muscles.

2. Those movements and attitudes which seem to be the result of the general excitement of the nervous system; as swaying of body, tapping with fingers or feet, and the like.

3. Certain postures, which may be the joint result of the withdrawal of the supervision of consciousness, and of the contractions which result from the general nervous excitement.

It is assumed that all mental effort is voluntary attention. This form of attention, we are told, is derived from spontaneous or natural attention, and is in the main a product of civilization, having developed out of the necessity for work.

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[1]Mantegazza, 2d edition. Paris, 1889, p. 171.

A brief discussion of some of its phases, and especially of its mechanism, will reveal the basis of the foregoing classification of effort expressions.

In the first place a comparatively low intensity of general awareness is the condition of consciousness in repose. To replace this with a high degree of special alertness, involves the repression of irrelevant sensations and ideas and the emphasis of the relevant ones. So difficult is the attainment of this state of attention that "it drains for its own use, at least in the proportion possible, the entire cerebral activity."[1] Not only do the vaso-motor changes, producing local hyperæmia of the brain, show this concentration of effort, but also the movements and changed attitudes of the body indicate such focalization. In that original and typical form, known as spontaneous sensorial attention, as when a child is captivated by a brightly colored object, the whole body converges toward the object, all the sense organs seem to have a focus at the same place and all motion is arrested. But the investigations in physiognomy show that these muscular contractions are not of equal value, either in relative energy or for the recognition, by an observer, of the nature of the conscious state. Just as consciousness is focalized, so the motor accompaniment tends to have its centre in the muscles of expression of the face and head. Mantegazza writes: "Intellectual expression groups itself always about the head, which is the seat of thought." Again, "If it is necessary to limit to the least space the field of the expression of thought, I include it in the space of some square centimetres which extends below the eyebrows and between them."[2] Piderit accounts for the face as the chief seat of expression partly on the ground that in the face the muscles lie stretched close upon the bones, so that the smallest trembling of a muscle is perceptible to the eye. Furthermore, the roots of the facial nerve arise in the brain in the immediate neighborhood of the "soul's organ," thus rendering spread of nerve currents to this tract especially easy. Lastly, the muscles of the face support the sense organs.[3] Chas. Bell held that the facial muscles assume their important rôle in expression because they are accessory to the muscles of respiration. Both facial and respiratory muscles are controlled by nerves whose nuclei are contiguous, and both assist in communication through their relation to vocal expression. It is here, therefore, that we should expect to

[1] Cf. "Psychology of Attention," Ribot. Chicago, 1894, page 4.
[2] Mantegazza, *op. cit.*, p. 173.
[3] Piderit, "Mimik und Physiognomik," p. 33, 2d ed. Detmold, 1886.

find the most characteristic motor accompaniments of mental effort.[1]

1. *Specialized Contractions.* As the phenomena of "normal expression" are to be considered here only in so far as they contribute to our knowledge of "common automatism," nothing more than a very general sketch of the outcome of the studies in this field is attempted. For more detailed account of the principles of expression, the reader is referred to the works of Darwin, Duchenne, Piderit, Mantegazza and others. One of the pioneers in the scientific study of "specialized contractions" was Duchenne, who considered that he had proved, by electrical stimulation of separate muscles, that a single muscle might be sufficient to the expression of thought or emotion. He called the *occipito-frontalis* (the muscle which lifts the brows) the muscle of attention, the *orbicularis superior* of the eye-lids the muscle of reflection. Darwin, whose great work[2] still remains perhaps the most important in this field, attempted to explain the origin of the association of certain expressions with certain mental or emotional states. Wundt, Piderit, Mantegazza and others have also attacked the problem of the origin of these expressions. Without discussing in detail the various principles invoked by these authors, suffice it to say that all agree that no muscles exist, as Duchenne and other earlier writers thought, simply for the purpose of expression. All now make large use of the idea that expressive movements are more or less weakened repetitions of movements that were once of utility, and becoming closely associated with certain mental states, tend to reappear when these states reappear. Darwin held that the raising of eyebrows in outward attention aids in opening the eyes for better vision. Opening of the mouth aids in intense listening and in the rapid catching of the breath which precedes muscular effort. This opening of the mouth tends to reappear in states of astonishment. The contraction of the muscles around the eyes, of which the primitive use, according to Darwin and Donders, is to protect these organs from being too much gorged with blood during the screaming fits of infancy, survives in adult life in the frown, which comes when anything displeasing presents itself either to thought or action. Mere effort of attention or reflection is displeasing, and thus the *corrugator supercilii* has been called by Duchenne the muscle of thought. The frown, says Darwin, is further developed by need of primitive man for best vision in search of prey or dis-

[1] "Anatomy of Expression," Charles Bell.
[2] "Expression of the Emotions."

tant enemies. Being bareheaded, the brows were contracted to shut out excess of light. Gratiolet calls attention to other useful movements that become associated with continual use of eyes, as closing of eyes and turning away of face when an unpleasant proposition is made,—a survival from disliking to see something unwelcome. In difficult recollection the eyes wander about as if trying to see that which is desired. Wundt, by his principle of reacting similarly to similar feelings, explains many of our expressions by reference to their analogy to "taste," etc. Many experiences are "bitter" or "sweet," and our behavior is the same that it would be if we actually experienced such tastes. Piderit also emphasizes the frequency of our responses to the fundamental senses. Preyer has explained the opening of the mouth in attention, and the protrusion of the lips, by reference to the fact that the first attention of all animals is directed to the search for food. "All examination of and all testing of food is attended by a predominant activity of the mouth and its adjuncts. Especially in sucking, which first awakens the attention of the newly-born, is the mouth protruded."[1] This often remains for years, and appears when attention is strained, especially in such activities as writing, drawing, and the like. Wundt and Piderit have also called attention to the fact that we tend to act as if the object of our emotion or thought were present to us. By intense attention the gaze is fixed on the object, also when the object of our attentive thought is not present, the gaze tends to become fixed. If we frown, we feel something in the eyes that reminds us indefinitely of a blinding light. Mantegazza regards the frown as due merely to sympathy through the contiguity of the nerve-centres of eye and brow.

Many writers have noted the firm closing of the lips during certain activities, and Darwin thought it was perhaps to prevent the respiratory movements interfering with the fine adjustments necessary, for instance, in threading a needle. Gratiolet considered it, since it appeared in effort, as a part of the action of deep respiration, which has for its purpose the retarding of circulation. Mantegazza also considers it as incidental to the deep inspirations which precede effort. Finally, a principle of antithesis is brought forward by Darwin, to account for a few phenomena of expression, as shrugging of shoulders. This principle is essentially that if a certain stimulus prompts a certain set of movements, then a contrary stimulus will prompt the contrary movements.

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[1] "The Senses and the Will," p. 303.

Although many of these suggestions seem plausible, the main impression produced by the literature of the subject is that we have only begun to realize the scope of the phenomena involved, and we can only hope for adequate treatment of "expression" when heredity in all its length and depth has been explored. A further conclusion is that the line between so-called movements of normal expression and the common automatisms is a vanishing one, and perhaps in the light of a larger survey of facts it may be shifted so as to include many, if not all, of the latter class.

2. *The Automatisms of the Second Group* are very numerous, and so great are the difficulties of explanation that only the most tentative classification is offered. In general these phenomena are products of the general nervous excitement which appears in mental effort. The following divisions may be made:—

A. Those movements which are simply the result of "diffusion." They include:

a. Movements due to defective inhibition; as twitching of eyes and fingers, squinting, and most cases of "nervous" movements.

b. Movements due to sympathy and imitation, as moving of jaws in unison with scissors, moving of head, tongue and lips with the rhythm of movements of the pen.

B. Those movements, whatever their origin, which help to maintain a sufficient excitement of the brain.

C. Those which serve as a "short-circuit" for such slight nerve currents as otherwise might reach the cortex and dissipate the concentration of consciousness present in mental effort.

These classes overlap to a very great extent, and the above classification is rather a statement of different points of view from which many of the same phenomena may be considered.

There can be no doubt that the effort of voluntary attention increases the activity of the central nervous system. The struggle for the focalization of consciousness, with the concomitant contractions of the muscles of the face and head, must unlock much energy hitherto latent. Again to quote Ribot: "A man worn out by a long walk, by great mental exertion, or who succumbs to sleep at the end of the day's task; a person recovering from a severe illness; — in a word, all debilitated individuals are incapable of attention, because like every other form of work it requires a reserve capital that may be expended. In passing from the state of distraction to the state of attention, there is accordingly a transformation of potential into kinetic energy." How much of

this increased activity is due to the reserve store already in the nerve cells, and how much is produced by the increased charging of the cells by the immediate augmentation of the flow of blood to the encephalon, cannot be determined. Whether the initial stimulus to this arousal of the brain comes from within, in the form of a spontaneous idea, or from without in the form of a sensation, the impressions which flood back from the muscles of expression (including the visceral and other involuntary muscles) may have an important function in further increasing the cerebral activity. The state of attention can be preserved, then, only in proportion as the supply of excitation is adequate. Thus the beating of the head, rubbing of the face, and the like, which by stimulating parts near the brain would be especially efficacious in keeping up the cerebral activity.

A further evidence of the excitement of the central nervous system is furnished by the general tendency to immobility of the body. This quiescence is manifestly not due to a relaxation, but to a contraction of opposing muscles, and consequently represents a considerable expenditure of energy. This excitement, if not under control, overflows and dissipates itself in more or less random movements. At best, voluntary attention is rarely sustained for any great length of time, and seldom is the bodily convergence complete. If the act of voluntarily giving one's-self to the consideration of a task is to be in any degree successful, there must be a considerable intensity of acquired interest and a high development of inhibitory power. The development of this control of mind and body is a slow and toilsome growth, and a brief discussion of its unfolding is of importance for our purpose.

The question of control is, in part at least, the problem of inhibition. The central nervous system has a regulated tone. It is a hierarchy of centres. Each centre tends to constrain and direct the movements of those below, and is in turn more or less controlled by those above. To mention a single illustration,—it is a well-known fact that the reflexes of a brainless frog are greater than those of the normal animal. All authorities agree that the highest control, expressed in such activities as are designated by the terms deliberation, choice, and will, are bound up with the integrity of the higher cerebral centres. Any defect of these centres results in disturbance of the normal activities of the organism, and may lead to grave motor derangement. Pathology presents a vast array of such defects. The prodigal activity of mania, the twitchings and automatisms of late stages of certain febrile disorders, many abnormal postures, and facial expressions of

victims of nervous disease, illustrate this deficiency of controlling power.[1]

In the normal infant, moreover, the higher cortical centres are as yet only slightly developed, and in consequence inhibition lags behind. The lower nerve centres, well nourished and inadequately connected with the higher centres, are discharging constantly into all the muscles, producing that restlessness which has been denominated the very essence of childhood.

The order of development of the nerve centres, then, is from the lower to the higher; from those which mediate coarse adjustments to those which subserve the finer and higher activities. Thus the centres for the body, those of trunk, neck, arms and legs, the so-called fundamental muscles, ripen much earlier than those of the vocal organs, fingers, toes, and the like, which are denominated the accessory muscles or organs. We find here, therefore, an explanation of the greater frequency of the common automatisms of the accessory organs. They elude control longer, and in the lives of most of us never yield implicit obedience.

Chorea, a typical disease of the growth period, shows many of the phenomena of infirmity of control writ large. It has been defined by Sturges as an "exaggerated fidgetiness." Its favorite age is from six to fourteen years. The parts of the body become subject to chorea in the order of the use as intelligent instruments. Untaught muscles and such as have never been employed as the agents of intelligence never suffer chorea. Arms suffer more than legs, fingers more than arms, and the face (among older children) most of all. "Chorea indicates the withdrawal or infirmity of controlling power."[2] Says Clouston, "I think it may be taken as a rule, with few exceptions, that the tissues, the organs and the functions which are of slow development are those which hereditary evil tendencies are most apt to influence."[3] The motor processes are not fully developed until the close of the period of adolescence. This tardiness of growth affords most favorable conditions for the development of inherited motor defect or the fixing of acquired peculiarities of posture and movement. The stress of environment is often too great for these unripe and unstable centres. The pressure of modern life, with its demands for a multitude of fine and precise ad-

[1]Cf. Bancroft, "Automatic Muscular Movements of Insane." AM. J. PSYCH., III, 4.

[2]Cf. Sturges, "Chorea," London, 1881; Sachs, "Nervous Diseases of Children," London, 1895; Donkin, "Diseases of Childhood," London, 1893; Clouston, "Neuroses of Development," London, 1891.

[3]Clouston, "Neuroses of Development," p. 7.

justments, is severest of all upon the accessory muscles, just those whose centres develop so late, and are consequently, in the child, least under control. Conventionality and social custom tend to repress the expression of feeling or thought. This operates to check the nervous exaltation and the intense expression of the young. The school demands bodily stillness, which requires a degree of self-control found only in the best trained adults. Because these conditions interfere more or less with the normal growth of the child, they tend to render inhibition permanently defective.

The natural imitativeness of childhood also contributes to the acquisition of new, or the confirming of old evil motor tendencies. The child sees a movement which he consciously or unconsciously repeats. The habit is quickly formed, and if it supplies an outlet for his energy, soon becomes unconscious, and thus so difficult of repression that it may survive for life.

These three factors, therefore—the enormous activity of the child, the inability to completely control his movements, and the proneness to imitation,—furnish the rich soil out of which spring many of the common automatisms.

The development of inhibition is clearly seen in the gradual disappearance of automatisms of the fundamental muscles, and later of the movements of the accessory muscles which might distract attention. It seems highly probable that most of the automatisms of a normal individual that survive, do so because they actually serve attention in ways soon to be considered. In the children, the automatisms of the head (neck muscles), body, legs and arms constitute 9.7 % of the total number reported, while the same movements and postures reported of adolescents are only 4.4 % of the total, showing a decrease with age of more than one-half. The returns do not show clearly the relative number of extravagant movements, such as indicate incipient nervous disorder.

A.—Automatisms due to Sympathy and Imitation. A child learning to write moves not only the writing hand, but also head, lips, tongue, and, in one case reported, the corresponding forefinger of the other hand. This illustrates the general fact that in acquiring any skill, the first movements employ more muscles than are later needed. Schneider's [1] simile states the case, "Imagine the nervous system to represent a drainage system, inclining on the whole toward certain muscles, but the escape thither somewhat clogged. The streams of water will, on the whole, tend most to fill the drains that go towards these muscles and to wash out the escapes. In

[1] Quoted from James' "Psychology," I, page 113.

case of a sudden flushing, however, the whole system of channels will fill itself and the water overflow everywhere before it escapes." In the child learning any difficult thing, there is this intense flood of energy and no sufficiently definite control of the motor centres involved. The overflow follows the path of least resistance. Hence the centres most affected will be (everything else equal) those most contiguous to the centres from which the diffusion spreads; secondly, those which belong to muscles most frequently employed (usually the smaller muscles); and lastly, those most frequently associated with the activity in question. Those parts of the body which comply with all three of the above conditions, manifestly will exhibit the greatest tendency to movement. Lips and tongue have centres not remote from that of the hand ; they are among the most frequently employed muscles, and finally there is evidence, from the facts of aphasia, that in most cases the motor speech centre is probably innervated whenever writing is performed. The movements of the corresponding finger of the other hand may be due to contiguity of the centres in the cord, and to close association of corresponding centres in the cortex. The head movements, intermediated by muscles of the neck, may be partly due also to contiguity. The idea of a rotary movement not only leads to such a movement of the hand, but also of the other mobile parts. Suggestion through the eye of the movement of the writing hand or of the pencil, may reinforce the tendency of the "automatic" movements to assume the same general form.

B.—Excitatory Automatisms. Certain automatisms appear in mental effort, even among the best trained thinkers. An eminent university teacher plays with watch-chain as he becomes most deeply absorbed ; a prominent United States senator plays with keys ; Lord Derby is said to have always chewed something when making the greatest mental effort, and so the list might be lengthened indefinitely. These automatisms can hardly be explained on the ground of defective inhibition. They are accessory to the mechanism of attention. In order that mental activity may be brought to its maximum, and kept there during a period of work, the circulation of the brain must be rendered adequate, and the latent energy of the nerve cells must be aroused. To aid in accomplishing this, many movements have appeared in the race and in the individual. Their sole *raison d'être* seems to be that they facilitate the work of the brain. Any sort of movement or stimulation may serve, provided it be not so great as to distract the attention. Prominent among the automatisms of the present group are those which are concerned with the stimu-

lation of some part of the face or head. This region is supplied by the tri-facial nerve, and excitation of this nerve seems specially efficacious in arousing the brain. Chewing has been shown to increase the carotid circulation. The use of tobacco, chewing gum, sweets, has been resorted to during periods of great effort of thought. These stimulate the facial nerve. Also the scratching of the head, or stroking of beard or moustache, pressing of forehead, rubbing of eyes, pulling at parts of face, striking the nose, illustrate the value of the stimulation of this nerve. Dr. Lauder Brunton also suggests that there may have been a similar reason for use of snuff. "The general titillation of the mucous membrane of the nose, probably serves to stimulate the cerebral circulation, and the increased arterial tension due to the effects of sneezing, so increases the cerebral nutrition that difficulties seem at once to disappear, and obscurities of mental vision are so rapidly removed that snuff is said in popular language to "clear the head." The above quotation is given for what it is worth, but it does tend to emphasize the very great importance of these stimulations of parts near the brain. Mantegazza distinguishes these movements from those in which the head and scalp are given blows which seem to increase cerebral activity by jarring the brain. If this explanation is true, he thinks it explains why some persons cannot think at their best except when in a carriage, on horseback, or in a boat. Besides the movements which stimulate the face and head, those of the fingers and feet seem also frequent and important. The "drumming" habits of many when in perplexity or deep thought, the need of walking in other cases, probably belong to this category. Slow rhythmical stroking of the head has an opposite effect, soothing rather than arousing the brain. This seems due to the fact that the organism is "set" for certain rhythmical stimulations, the diffusion of the regular impulses being slow enough to proceed without discharging much stored energy.

All active movements therefore, whether of face, hands, legs or feet, tend to increase the central excitement, and this in turn is the necessary condition of great intensity of attention. Movements too excessive, by distracting attention defeat their own purpose, and therefore tend to fall away in all individuals, excepting of course those in whom control is to a great extent deficient. And with these, any high development of the power of voluntary attention is impossible.

C.—Short Circuit Automatisms. Prof. James[1] has advanced the view that certain automatisms are protective of the state

[1] Cf. James' "Psychology," Vol. I, (pp. 457, 458).

of extreme attention. The activity of these movements, according to him, "drains away nerve currents, which if pent up in the thought centres would very likely make the confusion there more confounded. But may it not also be a means of drafting off all the irrelevant sensations of the moment, and so keeping attention more exclusively concentrated upon its inner task?" That automatisms may often play this rôle seems highly probable. But some automatisms appear before there is any considerable degree of attention to be distracted, and many of these or others continue more or less intermittently throughout the whole effort period. At the beginning they certainly seem excitatory. It would appear probable that these two functions, the excitatory and the protective, supplement each other. Prof. G. E. Müller[1] in discussing the well-known fact that the cessation of an unfelt stimulus may be felt, suggests "that impressions which come to us when the thought centres are preoccupied with other matters may thereby be blocked or inhibited from invading these centres, and may then overflow into lower paths of discharge." Now the automatisms at first aid in increasing the cerebral excitation. Under this favorable condition, or concomitantly with it, the state of attention waxes in intensity. When it reaches its height the blocking or inhibiting process may act to shut out the excitatory currents for the moment. Then the nerve paths of the automatisms become the channel for the drafting off of all currents which are excluded from the brain during attention, because "incidental stimuli tend to discharge through paths that are already discharging rather than through others."[2] Hence the movements tend to be kept up, but now serve a different purpose. Furthermore, attention fluctuates. With waning energy of brain, the wave of intensity of attention begins to fall and thus releases to some degree the inhibitions upon these currents flooding in from the contracting muscles, and thus these impulses again reach the brain, and again increase the excitement; only to be shut out again when attention reaches its maximum—and so on until the store of energy is exhausted or the task completed.

If this conception be true, it serves to explain certain important characteristics of automatisms. It is the experience of the writer, and also of others who have been questioned, that the movements preliminary to effort are often different from those which appear when attention is at its best. Moreover, the movements during effort tend to vary both in form

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[1] James, *ibid.*
[2] James, *ibid.*

and intensity. When sitting down to a task the arms may be stretched, or parts of the face and head rubbed, scratched or pulled with considerable energy. Or even sometimes the necessity of walking about the room seems imperative in order that worker may "pull himself together." The stretching and straining which often immediately precede the word "go" in an athletic contest are of the same violent sort. These represent the excitatory phase of the automatisms, and when the attention begins to weaken they often reappear again. On the other hand, when the work is under way and concentration seems at its best, the movements tend to become more intermittent and much less violent, and may appear simply as slight twitchings of parts of face, or drumming with fingers, and the like; which are frequently mere fractions of the former total movement. This would be expected, if the automatisms were at the time serving as short circuits for the more or less incidental currents which must be drafted off. That voluntary attention is a late product, and an incomplete copy of spontaneous attention, is shown by the very fact that it proceeds by such expensive devices as these automatisms. We need not look farther for an explanation of the more rapid fatigue in voluntary attention as compared with spontaneous. Lastly, if further observation and experiment should confirm the view of automatisms above suggested, this point of attack may furnish materials for a revision of the theory of attention.

3. *Automatisms of Posture.* Observation of children writing and at other tasks reveals a series of postures so significant as to demand special consideration. Forward bending of the body, with head very much too low, and perhaps on one side, with feet on sides or the sole of one pressed against the lower part of the other leg, represents fairly the usual posture of children in writing. In "recitation" standing on sides of feet is also very prominent. The whole attitude of the child here, as to a certain extent, also in any mental occupation which strongly claims the attention, is so suggestive of reversion that one can hardly escape the conclusion that we have here a return to fœtal posture, and even perhaps a recrudescence of the bodily attitude of man's more remote ancestors. The forward convergence of the body may, of course, be in part due to desire to bring the eyes nearer the object to which attention is given. Dr. Lauder Brunton[1] claims, furthermore, that forward inclination increases cerebral circulation and thus facilitates mental activity. This may have become automatic in the race, but after making allowance for such factors, there

[1] "On Posture and its Indications," *Lancet*, July, '92.

remains a third alternative, namely, that the general collapse of body is "atavistic." Every one knows how difficult is the preservation of the upright position of the body. It requires even in most adults, some supervision more or less conscious, and represents a great daily expenditure of energy. The general drooping forward of the body in fatigue shows how considerable has been the innervation of the muscles in maintaining erect posture. Preyer says that the ability to maintain a sitting posture appears comparatively late, the time varying with different children from the fourth to the eighth month.[1] We may assume, then, that it represents a difficult acquirement, and early in life demands a considerable conscious direction. There is further evidence that control never becomes entirely automatic even with such facile organs as the eyes. Donders holds that in reverie the eyes do not have axes parallel, but really slightly divergent; he also remarks that when one eye becomes blind it always, sooner or later, deviates outward. Le Conte[2] finds that the axes diverge "when we lose control over the ocular muscles, as in drowsiness, in drunkenness, in sleep, and in death." Such cases show clearly the need of control of the eye, in order that the organ may function properly. And if the eye muscles thus fall out of function when consciousness is at a minimum, as in falling asleep, or when the mind is completely absorbed, we can understand why other muscles released from restraint tend to do likewise. The "reductives," so to speak, that enable the centres of control to keep the body upright, are sensations of sight, and those that flood inward from the muscles involved. Now, when there is a low intensity of consciousness available for this function, as in sleep or in fatigue, or when consciousness is strongly focalized on something else, these cues are not appreciated, and in consequence the body and the limbs tend to relapse into those positions which, on the whole, are most habitual. From the standpoint of philogeny, the most habitual attitude must be the most primitive. That the muscles of these members are not relaxed, but contracted, as a result of the general excitement of effort, does not invalidate the explanation, inasmuch as the contractions would follow the same law of premature habit. It seems a generalization of wide applicability, that in proportion as the control of a part of the body declines, there is a tendency of those parts to lose the latest acquisitions and fall back as far as possible upon the primitive conditions.

[1] "The Senses and the Will," p. 267.
[2] "Sight," Le Conte, p. 255.

The points of this general discussion are put forward merely as suggestions, or even as speculations. At the same time their value will not be lessened by explicit formulation:

1. Many automatisms represent processes for the production and maintenance of central nervous energy, as well as for the protection of the state of attention. They may therefore be considered as important features of the mechanism of voluntary attention.
2. Other automatisms are the result of defective control, and consequently represent serious leakages of energy.
3. Many of the postures suggest reversion to fœtal postures and also to primitive attitudes.

While the questionnaire replies upon which this study is based, were too few in number to yield quantitative results of great value, the high quality of the returns nevertheless justifies the belief that they develop the salient facts concerning the subject in hand. The method is richly suggestive, and defines many problems which can be approached later by wide, systematic observation and experiment. To illustrate: It seems possible to determine experimentally the order in which the different automatisms in a given case arise and decline; the influence of the degree of effort and of fatigue upon these muscular contractions; and the relative influence upon cerebral circulation of the various automatisms. Pedagogically a knowledge of these automatisms is of immediate practical importance. If our classification is correct, these phenomena must not be indiscriminately dealt with in the child. While some automatisms deserve summary repression, many, because they are the means of developing working power, should not, at least, be discouraged. If still others are results of too great deficiency of control, the demand is for the most careful hygienic, if not medical, treatment. Moreover, the excessive movements which accompany the performance of any difficult school task, may serve as an index for a determination of the age at which these requirements may be safely imposed upon the child. If, for instance, in learning to write, the automatisms do not tend to fall away rapidly with practice, then it may be assumed that the centres and muscles involved are not ripe for such a task, and that the strain of performing it is likely to produce, not skill, but nervous disorder.

The writer wishes to express his very great obligations to President Hall, who directed attention to the problem and who coöperated in the collection of data; also to Dr. E. C. Sanford for many helpful suggestions.